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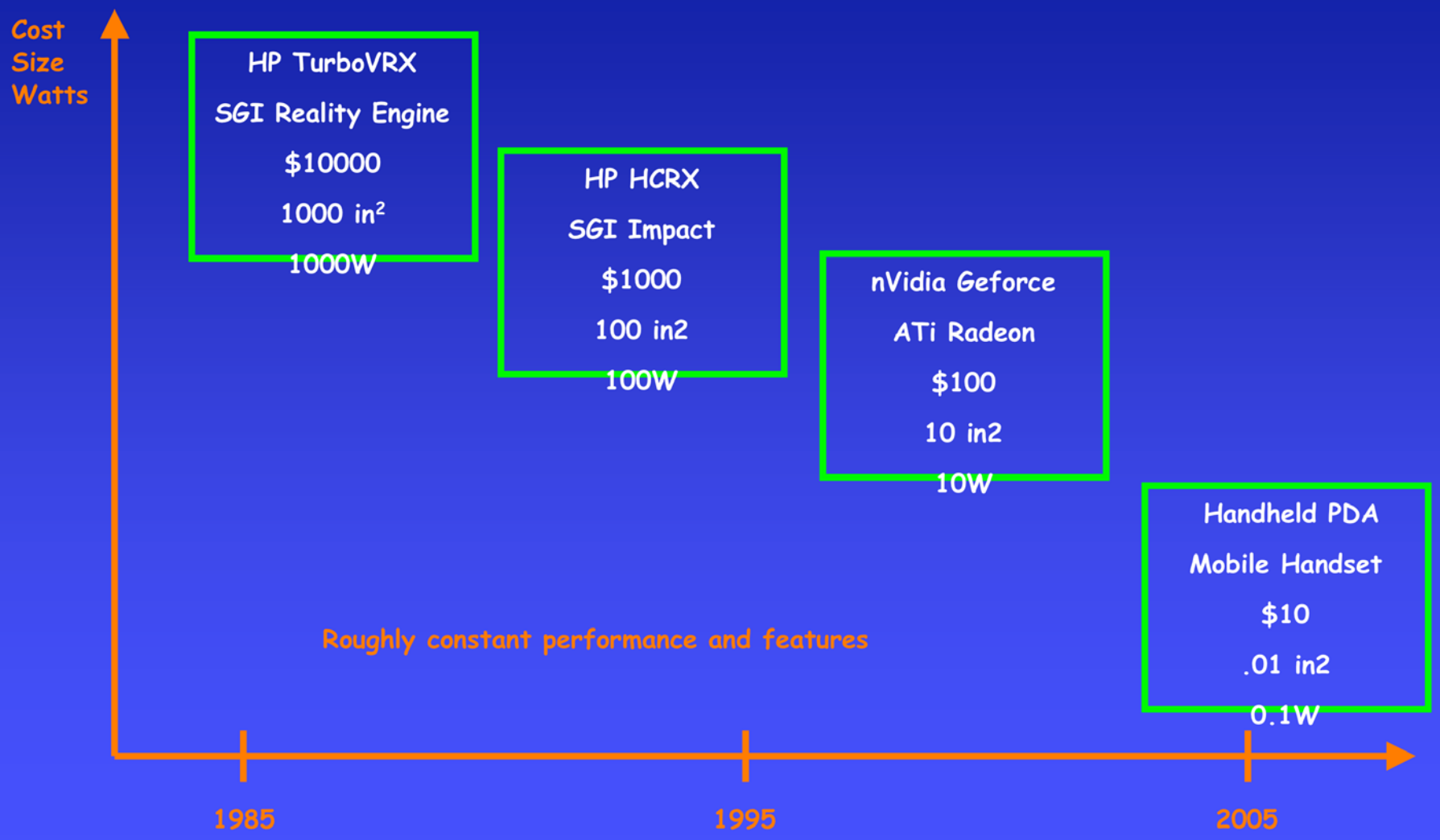
# Mobile 3D Revolution

## Astounding 3D graphics on your Smart-Phone

Enabling Technology Forums CES 2005

www.imgtec.com www.powervr.com www.metagence.com www.ensigma.com www.pure-digital.com

# 3D Graphics Evolution





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# Mobile Multimedia challenges

- High-performance, low-power 3D core more than silicon shrink
- Power budgets are 1/100th of desktop graphics
- Memory bandwidths available are tiny compared to desktop
  - At least 2 orders of magnitude available bandwidth gap
  - UMA vs. dedicated 3D memory - shared bandwidth
- Mobile processors are weak compared to desktop CPUs
  - 200MHz typical vs. 2GHz
  - Shorter pipelines, tiny caches
  - Memory capacity and bandwidth shared with multimedia engines
  - Typically no FPU
- Mobile multimedia architecture must rise to meet all these challenges


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# Mobile Multimedia needs

- Despite these challenges, handheld platforms must provide
  - Digital audio, digital video at set-top fidelity levels
  - Yet also provide long battery life
- 3D is the most challenging of all
  - 3D will drive the handheld market within 12-18 months
  - Handset manufacturers demand performance and quality
    - Equal to or exceeding 2 generations old desktop 3D
    - Yet only consuming milliwatts of power
    - With tiny memory bandwidth, shared with CPU
    - With a CPU of minimal floating point capability
- Shrinking Si processes / lower voltages help somewhat
- A radical new architecture is required to provide premium performance and quality while dropping size and power 2 to 3 orders of magnitude in one generation
- As an example, let's explore how PowerVR MBX achieves that


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# PowerVR MBX architecture design goals

- Support full OpenGL ES feature set
- Provide render/image quality of a 96 bit deep frame buffer
- Allow high-end triangle and fill performance
- Work in a limited resource mobile environment by minimizing
  - Power
  - Die size
  - Memory size
  - Memory bandwidth
  - Driving processor requirements

This was achieved by MBX's unique Tile-based Deferred Rendering

- Triangles are not rasterized as they are submitted, instead they are stored and processed in tile-order


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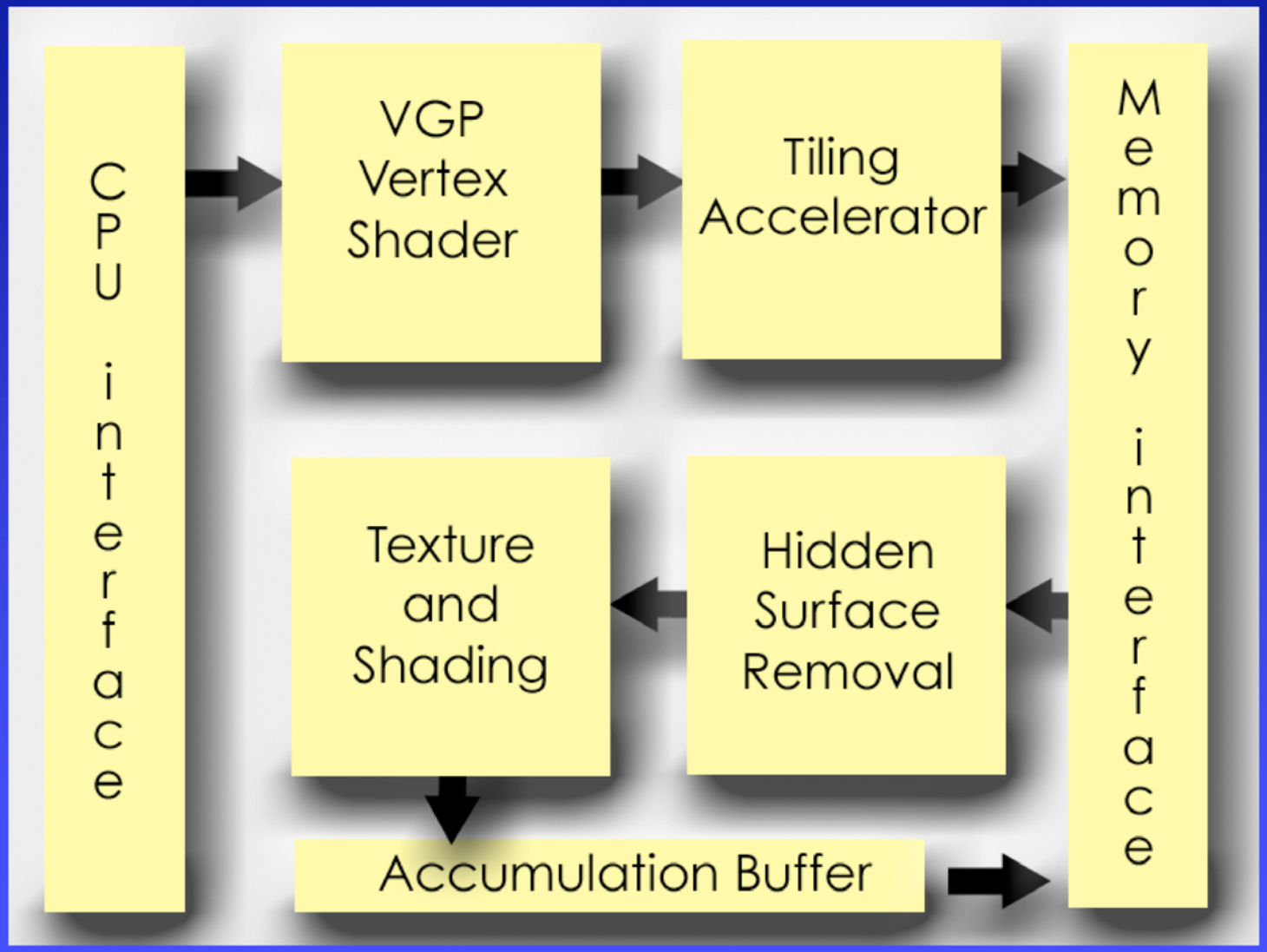
# PowerVR MBX architecture





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# PowerVR MBX architectural advantages

- VGP maximizes polygon performance from constrained, FPU-less CPUs
  - 4M triangles/sec achievable from 100MHz clock
- HW Tile Accelerator offloads CPU of complex triangle/tile management
- Bandwidth-intensive per-pixel operations happen on-chip
  - Z-buffer compare-replace, pixel blending
  - Only completed pixels are written to the persistent frame buffer
  - Multi-sample anti-aliasing is enabled at virtually no cost
  - 400M pixels/sec achievable at 100MHz clock
- Deferred texturing only accesses texture for observable pixels
- On-chip buffers are full-precision
  - Floating-point Z-buffer, 32-bit rgb$\alpha$
  - 16-bit display image quality is much higher than IMR
- Memory Coherence
  - Highly predictable texture cache behaviour
  - Framebuffer writes have improved page coherency
- Design time decision options for size-power-performance trade-offs


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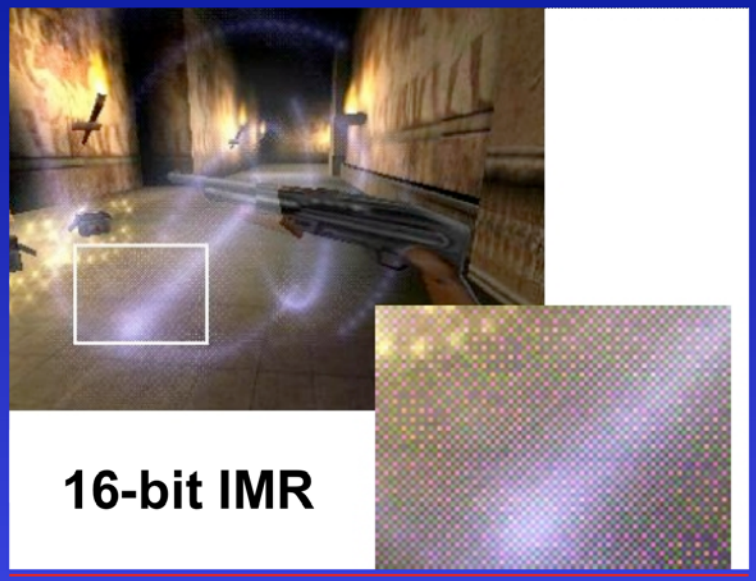
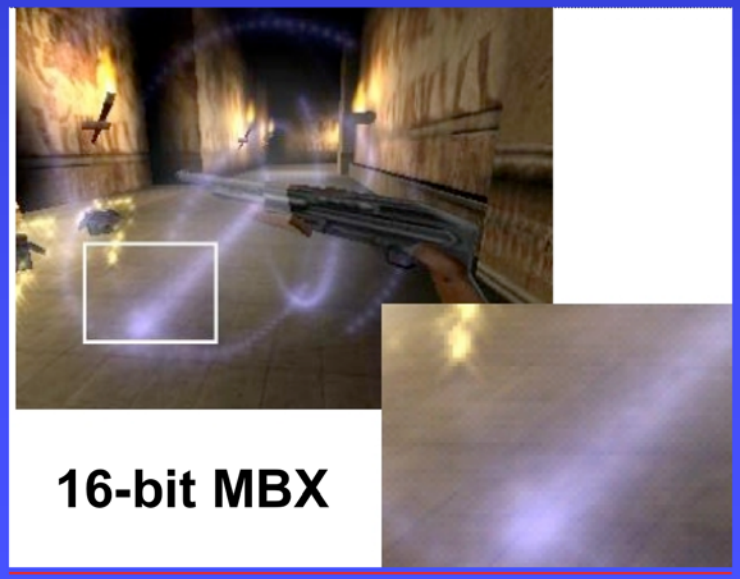
# PowerVR MBX quality advantages



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# Mobile 3D graphics SW support requirements

- 3D API's
  - OpenGL ES
  - Direct3D Mobile
  - M3G (JSR 184)
- Fully accelerated 2D on native windowing system
  - Direct Draw
  - X11
- Multiple CPUs
  - ARM9, ARM11
  - Intel Xscale
  - Renesas SH series
- Multiple operating systems
  - Microsoft Windows CE
  - Microsoft Windows Mobile
  - Linux
  - Symbian
  - µITRON


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# Mobile 3D will soon be ubiquitous

**Five of the top 10 semiconductor manufacturers (2003 revenues) have licensed MBX technology and two are currently shipping**

| | |
|---|---|
| Intel | $27b |
| Samsung | $10.4b |
| TI | $8.3b |
| Renesas | $8.0b |
| Toshiba | $7.4b |
| ST Micro | $7.2b |
| Infineon | $6.9b |
| NEC | $5.6b |
| Freescale | $4.6b |
| Philips | $4.5b |


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# Mobile 3D transition challenges

- Finding the killer app
  - Gaming?
  - GPS visualization?
  - Avatar?
- Porting existing applications
  - Limited resources
  - Large delta between 3D enabled and 2D only
  - Display size
- Performance benchmarks
  - Futuremark has released SPMark04 for Symbian mobile only


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# Mobile 3D explosive growth

- First high performance 3D PDA's shipped in 2004
- First accelerated 3D mobile phones will ship in 2005
- 3D in mainstream phones by 2006-2007
- Over 1 billion accelerated 3D handsets by 2008 projected


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